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# DESIGN AND FABRICATION OF HIGH PRODUCTIVE GRAIN GRADING MACHINE

**USMAN GHANI & KHIZERAZAM**

*Assistant Professor, Department of Mechanical Engineering, UET Peshawar, Jalozai Campus, Pakistan*

***ABSTRACT***

***Agriculture contributes almost 20% to the overall GDP of Pakistan & its production is about 40 million tons annually. The major crops of Pakistan include wheat, maize, rice, pulses. Since agriculture in Pakistan is gradually being commercialized, because of technological modifications, innovations and grouping rate of consumers demand keeping this importance under consideration, greater emphasis is laid upon production of value-added agricultural products rather than producing raw products not only domestically in Pakistan where consumer demand is growing but also globally it has been given greater consideration and therefore Pakistan also exports some of its agriculture products. The proposed research presents and focuses upon the production of value added domestic and household grains with minimal health hazards, power consumption, labor requirements and shorter lead time. The research combines the two traditional methods of household grains cleaning i.e. the concept of bamboos and wind cleaning is used to design most efficient, low cost and easy method to grade/clean grains domestically. The purpose of this research is also to develop a solution to the problems faced during traditional methods of grains cleaning i.e. microbial diseases through water polishing, labor fatigue in bamboos cleaning and power consumption through wind cleaning methods. The results show significant improvements in the traditional method of achieving 80% efficiency and these results are used to be implemented at households' levels to reduce the time, cost and power consumption in grains cleaning.***

***KEYWORDS: Grain Grading and Cleaning, Bamboos, Wind Cleaning & Shorter Lead time***

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## 1. INTRODUCTION

The greatest challenge of modern-day market competition is the supply of quality products in shortest period of time and fulfilling consumers demands. Since agriculture products such as wheat, Maize, Rice and pulses are consumed almost daily for food purposes therefore there is always a need of better nutritional quantity products. To achieve that goal better processed seeds could help in farming as well as in daily life consumption per capita, seeds after harvesting contain various wastes such as stems, rods, pots, stones, dusts and unhealthy grains and these all wastes have to be removed while utilizing post harvesting seeds for farming as well as in households**.** There are pre-defined methods for seed cleaning and grading but they possess some drawbacks which lead to lower quality and lesser availability of food grains. To overcome these drawbacks, an idea is developed to achieve maximum production and better nutritional quality. Grains grading/cleaning is the technique used to remove undesirable material and dockage from the grains and providing good quality of grains through cleaning procedures. These undesirable materials include stones, impurities like weeds, immature seeds, inert matters, straws, infected seeds, mud and soils remains. Grains, as it comes from the field, contains various contaminants like weed seeds, other crop grains, and such inert material as stems, leaves, broken grains, and dirt. These contaminants must be removed, the clean grains properly handled and stored to provide a high- quality planting grains that will increase farm production and supply uniform

raw material for industry.

Taking into account the limitation of the methods for grains cleaning, the idea developed was supposed to overcome the shortcoming. To achieve that, multiple brainstorming sessions were conducted in order to devise the best possible solution to the problem, the results achieved have proven importance and advantages, having reduced the costs, efforts & power consumptions. It is state of the art 1st generation grain grader having economic viability and potential for commercial utilization throughout its life cycle. Apart from that, it would also help in waste allocation which could be used for producing bio-fuels. Considering those benefits there is a great potential for the product in coming future with improvements and enhancements. Pakistan is an agriculture country and its 20% GDP lies on agriculture exports. Production of wheat grains, maize and rice are major constituent of that agriculture economy. Every year large amount of such kernels is damaged and wasted due to poor handling, cleaning and storing process, methods and techniques. Considering the agriculture history, we got that hundreds of tons of grains are wasted due to poor cleaning methods and grading methods which affect agriculture economy and farmers. Farmer's community and labor community related to agriculture field are affected due to such losses to their crops and grains. Various methods of grains grading are used at industrial level where there are milling processes but these methods can't provide real time benefits to the farmers and secondly there are transportation problems. These grading machines are highly expensive and ordinary farmers can't afford such machines for grading and cleaning processes.

There are agro-industries on domestic level in Pakistan that are contributing in agriculture fields but these industries do not have good quality production methods of grading grains and storing them in right positions with skillful techniques. Secondly, grains on handling after harvest contain various proportions of material other than grains (MOG) such as stone, pod, stem and dirt. Separation of the MOG is essential to upgrade the quality of food material. Grading result in reduced bulk of the material, high value products, safe and longer storage, more out-turn of better-quality milled products. Improper grading usually results in cost loss. Cleaning helps to reduce bulkiness during subsequent post-harvest operations. To remove straw pieces, unfilled grains and other foreign materials, cleaning and winnowing can be done manually, using wind energy or with the use of machines.

### 1.1 Problem Statement

Grains after harvesting contains different kinds of wastes which results in the problems like nutritional hazards, grains loss and lesser availability of food grains. The most traditional household grain cleaning techniques and their disadvantages are given in Table 1.1

**Table 1.1: Traditional Household Grain Cleaning Techniques and their Disadvantages**

| Bamboos cleaning | Wind cleaning | Water cleaning | Sieves Separator |
|---|---|---|---|
| Fatigue oriented in labours | Pollution causing | May cause microbial disease | Fixed vibration frequency |
| Time consuming | Power consuming | Time consuming | Fixed meshes |
| Lower capacity | No waste allocation | Worst quality flour | Limited application |
| High labour cost | Stones still remains | Lesser availability | High installation cost |
| Dust remains | black kernels still remain | Lead in health hazards | Larger space occupied |
| No proper waste allocation | Earth pellets may remain | | |

These mentioned methods present results in various drawbacks and lacking quality. Thus, to overcome these defects, an idea is developed to combine those traditional methods to achieve maximum production & quality.

### 1.2 Objectives

The grain cleaning machine is an electrically powered source to provide ease and efficiency to clean grains. In turn, it increases rate of returns over exports and to the poor farmers at domestic levels and enhance food quality. The objectives of the proposed research are:

- To meet the new and innovative machinery for agriculture grains cleaning.
- Sustainable and profitable production.
- To minimize Lead time and improve availability.
- Minimizing health hazards.
- To minimize power consumptions and labor cost.
- Provide ease of portability for multiple applications i.e. Grading/Cleaning.
- Provide ease of portability for multiple grains i.e. Wheat, Maize, Rice, Pulses.

## 2. LITERATURE REVIEW

Early history reveals that grains grading was done through sieves, bamboos and water. These methods were time consuming methods with stress and fatigue generation to bodies' parts and causing respiratory infected problems. No good quality of grains can be obtained from such methods. These methods were less affected for grain grading approach with less yield production capacity. These grading methods were not providing real time benefits to farmers, consumers and economic growth. So further advancement was needed for grains grading industry to meet desired measurement and requirements. Further advancement in agriculture technology cause great impact on grading industry. New grading machines are now available having different grading techniques and purposes. Manufacturers of grain grading machinery have done an outstanding job in developing processing equipment. Some of the present grain cleaning machines make extraordinary separations of small crop and weed seeds; however, the entire grains cleaning problem is very complex, and improvements are still needed in methods and equipment to reduce the heavy grains losses.

Chethana, T. V. and Ramesh, D. (2014) developed a low cost, pedal powered machine that is designed using readily available parts. Innovation in its simple design using bicycle components, which is easy to operate and without using electricity. Nagesh S. et al. (2014) developed a grain separator machine that decrease the time required for dust separation. Irtwange, S. V. (2009) worked on a motorized cowpea thresher using astar-shaped beater to which beater belts were attached was designed and locally built. U.S. Muhammad et al (2013) sorted the food grains of different sizes, and also polish them at a time in three categories i.e., coarse, medium and fine grains. MeeshaPunn and NidhiBhalla (2013) have done wheat classification by using two machine learning algorithms, that is, Support Vector Machine (OVR) and Neural Network (LM). For classification, images of wheat grain are captured using digital camera and thresh holding is performed. Other researchers who have worked in this research related area are Amitabha Ghosh et al. (1998), Vejasit and Salokhe (2004), Mulleriyawa R (2008), S. V. Irtwange (2009) and just to name a few. Much grains cleaning should be done in the field before the crop is harvested. Good cultural practices like spray programs, crop rotation, and rouging can minimize many serious weed and contaminant problems. When a grains lot enters the processing plant for cleaning, contaminants are removed by the use of special equipment that takes advantage of differences in physical characteristics of

various components in the mixture. Characteristics used in making separations and grading include size, shape, density, surface texture, terminal velocity, electrical conductivity, color, and resilience.

Many types of grains cleaning and grading machines are available that exploit the above physical properties of grains, either singly or in some combination. There are air-screen cleaners, specific gravity separators, pneumatic separators, velvet roils, spirals, indent cylinders, indent disks, magnetic separators, electrostatic separators, vibrator separators, and others. The most widely used machine is the air-screen unit. It is common to all grains cleaning plants from the small farm operation to the largest commercial installation. All the other separators can be considered secondary machines which follow the air-screen unit in the processing sequence. The choice or requirement of machines used and their arrangement in a processing line depends primarily on the grains being cleaned, the quantity of weed seeds and other contaminants in the mixture, and the purity, quality, capacity requirements that must be met. Grains for planting is of little value unless it reaches the farmer in a viable condition, essentially free of contaminants, and at a price he can afford. The degree to which these requirements are satisfied is related to the equipment used, its arrangement in the processing plant, and the knowledge and skill of the man operating the machines.

## 3. MATHEMATICAL MODELING FOR BASIC COMPONENTS

### 3.1. Meshes Mass & Dimension

Material: Mild steal

No of meshes = 3

Length = 24” = 24 x 0.0254 = 0.61m

Width = 18” = 18 x 0.0254 = 0.46m

Thickness = 0.08 = 0.08x 0.0254 = 0.002m

Gape between each mesh stage = 3” = 3 x 0.0254 = 0.0762

Average mass of one mesh = 0.8 kg

Total average mass of 3 meshes =3 x 0.8 = 2.4 kg

Total feed per cycle = 12kg

Pay load per mesh = 500gm = 0.5 kg

Total pay load per cycle = 500 x 3 = 1.5 kg

Area of mesh = Length x width = 0.61 x 0.46 = 0.28 $m^2$

Total mass = (total avg mass of meshes + payload on meshes)/ Area

= 0.8 kg + 0.5 kg / area = 1.3/0.28 = 4.64 $kg/m^2$

### 3.2. Grading Unit Mass Calculation

Material: Mild steal

Orientation: Angle iron

Dimension: L = 24” x 0.0254 = 0.61m

W = 18.5” x 0.0254 = 0.47m

Side = 0.75” x 0.0254 = 0.02m

Mass (L) = 0.54 kg

Mass (W) = 0.41kg

Number of units used: Length wise = 6 x 0.54 = 3.24 kg

Width wise = 6 x 0.42 = 2.46 kg

Total mass = 2.4 kg+ 1.5 kg + 5.7 kg + 0.5 kg= 10.1 kg

### 3.3. Throw plates

Dimension: L= 2.55” x 0.0254 = 0.063m

W = 1.5” x 0.0254 = 0.038m

T = 0.47” x 0.0254 = 0.012m

Mass per plate = 0.25 kg

Number of plates = 4

Total mass = 4 x 0.25kg = 1 kg

Counter mass added = 1kg

Diameter of shaft:D = 0.67” x 0.0254 = 0.017m

Length of shaft:L = 32” x 0.0254 = 0.81m

Mass of shaft: 1.3kg

### 3.4. Mass of Pulleys

Diameter: D (1) = 9” x 0.0254 = 0.23m

D (2) = 10” x 0.0254 = 0.254 m

A number of pulleys are used:

2 x 9”

2 x 10”

Mass of pulleys:

Mass of 9” pulley = 1.6 kg

Mass of 10” pulley = 1.72kg

Total mass at driven shaft = mass of crank + throw plates + countered mass + pulleys + shaft

= 1kg + 1kg + 3.2 kg + 3.44 kg + 1.36 kg= 10 kg

Cumulative mass = meshes + Feed + mesh frame + driven shaft

= 2.4kg + 1.5kg + 6.2kg + 10kg + 0.5kg = 20.1 kg

**3.5. Force Calculations**

Sliding force**,** F = µ (f normal)

F (normal) = total mass x g = 10.1 x 9.8 = 99 N

F (sliding) = FN x µ = 99 x 0.57 = 55.9 N

Total Force, F (total) = F (normal) + F (sliding) = 196.98 + 55.9 =252.9 N

**3.6. Stroke, amplitude of vibration**

Stroke/radius = 1.25" x 0.0254 = 0.032m

Total amplitude = 2.5" x 0.0254 = 0.064m

K.E = stroke x total force= 0.064 x 252.9 = 16.5 Nm

Since K.E = ½ mv^2

19.15 = ½ (20.1) V^2

2(16.2)/20.1 = V^2

V = 1.27 m/ sec

Since V = r w

w = V/r = 1.27/0.032 = 39.75 rad/sec = 2(3.14) N / 60

N = w x 60 /2 (3.14) = 39.75 x 60 / 2(3.14) = 380 RPM

**3.7. Power required**

P = F (total) x V (linear velocity) = 252.9 x 1.27 = 321 watt

**3.8. Belts from motor to support shaft**

V belts of A-Type are used with following specifications

Nominal width = 0.013m

Nominal Thickness = 0.008m

D (Diameter of Larger Pulley) = 2 inch= 0.051m

d (Diameter of Smaller Pulley) = 2 inch= 0.051m

C (Central distance between Pulleys) = 13 inch= 0.33m

Length of the belt, L= $\left[2C + 1.57(D + d) + \frac{(D-d)^2}{4C}\right]$

= 2(0.33) +1.57 (0.051+0.051) + (0.051-0.051)=0.82m

Allowable Power, Ha= $k1 * k2 * Htab$=1*0.85*250= 212.5 watt

Designed Power, $Hd = H\ nominal * Ks * nd$ = 373*1.1*1= 410 watt

Factor of Safety, $nfs = \frac{Ha*Nb}{H\ nominal*Ks} = \frac{212.5*2}{373*1.1}$= 1.04

## 4. CAD MODELAND FABRICATION

CAD and fabricated model of the grain grading/cleaning machine are shown in figure 4.1.

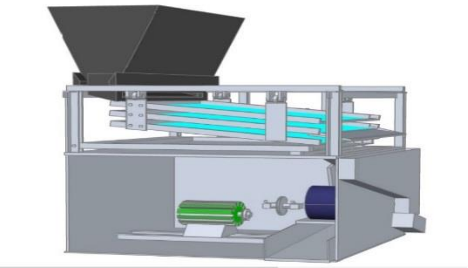

**Figure 4.1: Cad and Fabricated Model of Grain Grading/Cleaning Machine.**

Fabrication of the main components are given in tabulated form.

**Table 4.1: Fabrication of Main Frame**

| Operation | Machine | Time |
|---|---|---|
| Cutting material in required size | Power hack saw | 1 hour |
| Finishing edges | Grinding machine | 30 min |
| Welding angle iron | Electric arc welding | 2 hours |
| Finishing the welding | Hand grinding machine | 20 min |
| Cutting metal sheets for frame | Cutting machine | 20 min |
| Welding sheets on main frame | Electric arc welding | 1 hour |
| Finishing the welding | Hand grinding machine | 20 min |

**Table 4.2: Fabrication of Main Frame Base for Motor and Waste Collection Trays**

| Operation | Machine | Time |
|---|---|---|
| Cutting angle iron to required size | Power hack saw | 10 min |
| Grinding sharp edges of angle iron | Hand grinding machine | 10 min |
| Drilling for mounting motor | Drilling machine | 10 min |
| Welding angle iron for motor and waste trays | Electric arc welding | 20 min |

**Table 4.3: Fabrication of Crankshaft**

| Operation | Machine | Time |
|---|---|---|
| Cutting shaft to the required size | Power hack saw | 10 min |
| Facing the surface of shaft | Lathe machine | 10 min |
| Central drilling for mounting shaft | Lathe machine | 20 min |
| Plain turning of shafts to required size | Lathe machine | 2 hours |
| Cutting throw plates for connecting rings | Power hack saw | 10 min |

| | | |
|---|---|---|
| Drilling for assembling components | Drill machine | 20 min |
| Threading on shaft and inner in plates | Taps and die | 1 hour |
| Slotting for mounting keys | Milling machine | 2 hours |

**Table 4.4: Fabrication of Grading Unit**

| Operation | Machine | Time |
|---|---|---|
| Cutting the angle iron to required size | Power hack saw | 20 min |
| Finishing the sharp edges of the angle iron | Grinding machine | 10 min |
| Welding the angle frame to mount meshes | Electric arc welding | 30 min |
| grooves for meshes and welding square pipes | Electric arc welding | 30 min |
| Grinding the welded joints and finishing | Grinding machine | 10 min |
| Drilling hole for enhancing slope of grading | Drill machine | 10 min |

**Table 4.5: Fabrication of Hopper and Hopper Frame**

| Operation | Machine | Time |
|---|---|---|
| Cutting metal sheets to the required size | Cutting machine | 30 min |
| Welding the sheets | Electric arc welding | 30 min |
| Welding pipes at upper surface of hopper | Electric arc welding | 30 min |
| Finishing the welded joints | Grinding machine | 15 min |
| Drilling the hole for feed control valve | Drill machine | 5 min |
| Welding the plates with the threaded bolt | Electric arc welding | 25 min |
| Cutting angle iron for frame | Power hack saw | 20 min |
| Welding angle iron for hopper | Electric arc welding | 20 min |
| Slotting for mounting keys | Milling machine | 2 hours |

**Table 4.6: Fabrication of Pulleys**

| Operation | Machine | Time |
|---|---|---|
| Facing the pulley | Lathe machine | 20 min |
| Drilling the hole in the pulley to required size | Lathe machine | 30 min |
| Slotting the key | Broaching | 1 hour |
| Drilling in the pulley for bolt | Drill machine | 5 min |
| Threading in the hole | Tap and dia | 15 min |

## 5. TESTING AND RESULTS

The testing section includes the tests conducted upon the machine during its running time. Following types of grains i.e. wheat and maize were initially tested and performance was evaluated.

### 5.1 Wheat

While testing conducted for wheat cleaning meshes were arrange in different orders to ensure the proper cleaning of wheat.

#### 5.1.1 Feed Rate Test

- Pulley ratio was 5:1 and RPM of the crank rotation was 290 for wheat.
- The slope was made $2^{\circ}$ with x axis for wheat to increase the contact time.

- The feed was allowed to flow through to control valve.
- The mesh with maximum hole diameter was used at 1st stage.
- The 1st mesh help to remove the waste like stems, rod, pods from grains and feed was allowed to pass through to 2nd stage.
- In the 2nd stage the mesh with hole diameter greater than maximum grade of grains was used.
- The 2nd stage help to remove containments like stones and other wastes greater than the size of wheat.
- The very last stage mesh with hole diameter lesser than the smallest grains was used.
- The 3rd stage help to remove dust particles and black round kernels.
- This grading does not ensure the complete cleaning therefore in the very last stage the light air blower with variable speed was used.
- Light air blower helps to remove the dust remains and other waste from the grains.
- Waste was collected in three channels, first just after the two meshes and further from second & third mesh respectivelyand after light air blower.

**5.1.2 Cycle Time Test**

The total cycle time for 15kg feed was observed to be about 5 minutes.

**5.1.3 Power Consumption Test**

The overall power consumptions for one cycle was found to be 0.5 unit of electricity/hour.

**5.1.4 Quality & Performance Test**

The efficiency of operation and feeds cleaning was in the range of 80 -85%.

The results obtains from experimentations conducted for several cycle are given as follows:

**Figure 5.1: Unclean and Clean Wheat Grains.**

**5.2 Maize**

While testing conducted for maize cleaning meshes were arranged in different orders to ensure the proper cleaning of wheat.

### 5.2.1 Feed Rate Test

- The pulley ratio was set initially at 5:1 and the RPM of crank was 290.
- The slope was reduced further to $0^{\circ}$ to make sure grains have maximum contact time.
- Mesh with hole diameter greater than maize max size is used at 1st stage.
- Waste such as mud and other containments from maize cone parts having size greater than maize are removed at 1st stage.
- The 2nd mesh mounted is so designed to have hole diameter greater than equal to max size of maize grains.
- The 2nd stage help to removes the wastes which are slightly greater than max size of healthy grains.
- In the 3rd stage the mesh is mounted to have hole diameter lesser than minimum grain size.
- In the 3rd stage minute containments such as broken grains, black kernels, pods, stones are removed and collected in waste tray.
- Finally, through light air blower the fish's fins like light weight particles were removed.
- Wastes were collected in waste chamber while feed in feed collection chamber.

### 5.2.2 Cycle Time Test

The cycle time for 15 kg of feed was found to be about 8 minutes.

### 5.2.3 Power Consumption Test

The whole power consumption for an hour running time was found to be 0.373kwh and electricity consumption was about 0.5 unit of electricity / Hr.

### 5.2.4 Quality & Performance Test

The efficiency of operation and feeds cleaning was in the range of 80 -85%.

The results obtain from experimentations conducted for several cycle is given as follows in figure 5.2.

**Figure 5.2: Unclean and Clean Maize.**

## 6. CONCLUSION AND FUTURE RECOMMENDATIONS

The main aim of the study was to investigate the problem associated with house hold grain grading methods. Those problems arose from bamboos cleaning (labor required, labor fatigue, lesser rate of grading), water cleaning (microbial

disease, moisture in the grains, unavailability of grains) and air cleaning (power consumptions, contaminations in the environment, lesser efficiency). These problems have been sorted out and better and effective technique being define for grading and cleaning of grains with following benefits:

- Lesser power consumption
- Better and efficient with 80- 85%
- Multiple grains grading/cleaning is possible
- Almost affordable for every level of farmers
- Better cycle time than any alternative present for grading
- Machine cover its installation cost within six months of running time

To defend and achieve our initial goals and stated objectives, we have devised the best possible design but there are certain modifications which can improve the results and more benefits could be achieved to increase customers and commercial reliability and usability.

- Downscaling the initially prototype of this project to more robust and compatible size.
- The grading unit required 1 more stage to reduce the grains loss.
- It can be explored to milling unit in collaborations to clean and mill the grains at the same time.
- Waste chambers and channels could be made to utilize waste for making biofuels.
- A gear mechanism could be used to vary RPM of the shafts for multiple applications of grains.
- A solar panel can be installed to utilize at those places where no electricity is available.

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